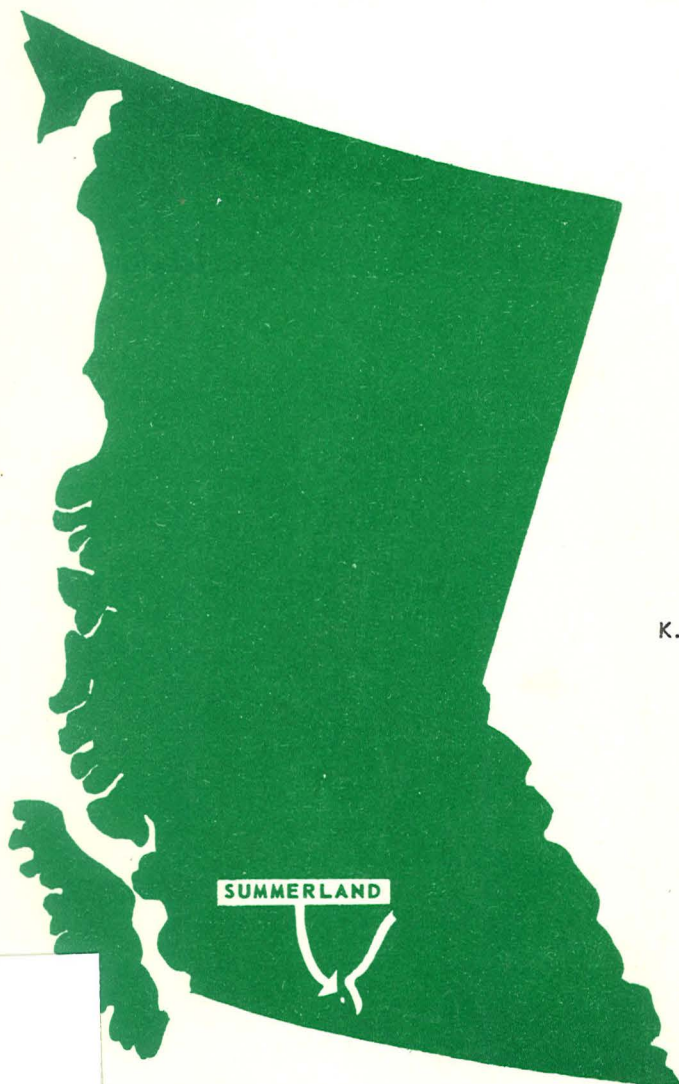


**COLD HARDINESS
OF ROOTSTOCKS AND FRAMEBUILDERS
FOR TREE FRUITS**



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This bulletin provides a brief summary of present knowledge about cold hardiness of tree fruit rootstocks and framebuilders. The information was assembled from all available scientific and popular publications on the subject. The bulletin is mainly intended for professional workers in research and extension, but progressive nurserymen and fruit growers also will find it useful.

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FOR TREE FRUITS¹

K. Lapins

INTRODUCTION

The use of clonal rather than seedling rootstocks, especially for apples, has greatly increased in North America in the last ten years. The increase is greatest in British Columbia, where a decade ago seedling rootstocks mainly were used, but now most apple trees are propagated on clonal stocks. A similar trend is apparent in Western United States and to a certain extent also in Eastern North America. Suitable size-controlling clonal rootstocks also are sought for other tree fruits, especially cherries, pears, and peaches.

Most clonal rootstocks, such as the apple stocks of the Malling (M) and Malling-Merton (MM) series, quinces, and plums, originated in Western Europe and were not selected for cold hardiness. The question of cold hardiness becomes important when these stocks are introduced into areas of low winter temperatures.

Extensive data have been collected on cold damage

1

Contribution B6, Canada Department of Agriculture, Research Station, Summerland British Columbia.

to rootstocks in fruit-tree nurseries and orchards following severe winters in Central Europe, particularly Germany (2). The data obtained in North America are less extensive but are of particular value for this area. A valuable summary on hardiness of the Malling apple rootstocks in America is given by Zeiger and Tukey (76).

The present report is a summary of information on cold hardiness of fruit tree rootstocks and framebuilders in commercial use in Canada or of those which show some promise for future use here.

SCOPE OF INFORMATION

The sources of the information in this report are scientific and popular publications and some unpublished data made available by research and extension workers, including results obtained at the Research Station, Summerland, B.C.

In order to present the data in the simplest form, all the basic information is tabulated, the rootstocks being grouped into five hardiness classes from very hardy to very tender. The original data were usually descriptive; they gave the comparative hardiness of varieties or the percentages of plants killed or injured (slightly, moderately, or severely) under certain conditions. Where hardiness groups were given, the classification was not always comparable to that in another

experiment conducted under different conditions. A variety found tender in Manitoba might have been classified as hardy in British Columbia. Consequently, adjustments in this report are made to take into account the severity of the test. Undoubtedly, many factors other than minimum temperatures may have affected the extent of cold damage reported in the various publications. Among them are: (1) time of year when the cold damage occurred, observations were made, or samples for freezing tests were taken, (2) temperatures prior to cold period, (3) tree vigor and tree health. Unfortunately, these factors, even if known, could not be considered in the summarized tables of this publication. Therefore, the relative hardness of the varieties in each comparison is the main consideration. Comparison of varietal standing within one experiment may be well interpreted and represented in tables; however, comparisons between different experiments are more difficult to make. To give full meaning to comparisons between experiments the conditions of the experiment or observation must be known.

In a few instances the plant material within one comparison is subdivided into groups A, B, C, etc. Although originating from one publication, these groups represent rootstock comparisons in different locations; different experiments,

such as artificial freezing trials or years; or different material subjected to freezing, such as roots and shoots. Cold hardiness values of roots and shoots are compiled in the same tables, since in cases of cold injury under natural conditions the type of damage has not been always recorded in the original reports.

It is believed that a better classification is produced by presenting the cold hardiness of rootstocks and framebuilders separately since the latter normally are hardier than the former. Certain standard varieties are often included in tables to show the relative standing of the lesser-known varieties of framebuilders or rootstocks. The data on framebuilder hardiness were not necessarily observed as injury to trunks or framework of the tree. In some instances the data had been collected from orchards or nurseries where the framebuilder varieties were grown as top varieties and terminal growth was injured.

The rootstocks and framebuilders are tabulated separately for apples, pears, and cherries; those for plums, peaches, and apricots are combined in one table. The listing of certain rootstocks in the last-named table does not necessarily mean that a particular rootstock can be used for plums, peaches, and apricots. No attempt is made to qualify root-

stocks or framebuilders in any other respect than for cold hardiness. However, certain lesser-known rootstocks are included in the tables if they show promise based on the descriptions in the experiments reviewed. Entries in each table are in chronological order of report.

Following each table, a brief summary on hardiness is given for the rootstocks or framebuilders included in the table. Those varieties that appear in tables only once or are little used are usually omitted from summaries. An attempt is made to interpret the discrepancies in the relative standing of varieties in different observations. This attempt considers the extent of plant material under test and the extent of segregation of varieties into hardiness classes in each experiment.

A summarized hardiness rating immediately follows the variety name. If this rating is expressed in more than one word, as a range of hardiness, then the emphasis should be placed on the rating which appears first. For instance, the rootstock rated as "hardy to moderately hardy" is hardier than that rated "moderately hardy to hardy".

EVALUATIONS OF HARDINESS

The basic data are given in Tables 1,2,3,4,5, and 6, respectively, for apple rootstocks, apple framebuilders,

pear rootstocks, pear framebuilders, cherry rootstocks, and plum, peach, and apricot rootstocks. Brief summaries follow each table.

Apple Rootstocks

Table 1. Hardiness grouping of apple rootstocks

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference number
	M. XVI	M. IX	M. IV	M. II M. XI	58
		M. I M. II M. IX	M. IV M. XVI	M. VII	66
	Antonovka sdg. Charlamoff sdg.		French Crab sdg.		4
	M. I	M. II	M. IX		67
	M. III M. VII	M. IV			
	M. XVI				
		M. III (A)	M. IV (A)	M. I (A)	63
			M. VII (A) M. XVI (A)	M. II (A) M. IX (A)	
		M. III (B)	M. I (B)	M. II (B)	
		M. IV (B) M. VII (B) M. XVI (B)	M. IX (B)		
	M. XI	Apple sdg.	M. I	M. II	57
	M. XVI	M. IV		M. IX	
		M. I M. II	M. VII	M. IV M. IX	51
M. robusta No. 5			M. XII	M. I M. II M. IX	16

Table 1. (Continued)

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference number
	M. XVI	M. IV M. VII M. IX M. XI	M. I M. II		27
		M. XVI	M. IX	M. I M. II M. IV M. VII	49
	A 2 M. XI	M. XVI		M. I M. II M. VII	41
	M. III	M. VIII		M. IX	46
	Manchu Crab	M. IV	M. IX		19
	<u>M. robusta</u> No. 5	A 2 M. XI	M. VII M. IX	M. IV	52
<u>M. baccata</u> sdg.				M. I M. IX	5
	Grahams sdg.	Antonovka sdg.			29
	Jakobsapfel sdg.	Bitterfelder sdg.			
	<u>M. prunifolia</u> Sikora sdg.	Kleiner Langstiel sdg. Trierer Weinapfel sdg.			
	M. XI	M. VII	M. II	M. I	42
	M. XVI		M. IV		
	M. II (A)		M. I (A) M. IV (A) M. IX (A) M. XI (A)		77

Table 1. (Continued)

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference number
R 7 (B)	¹ M. XVI (B)	R 12 (B)	M. III (B)	M. VII (B)	77 (Contd.)
R 9 (B)	Northern Spy (B)		R 900 (B)		
R 78 (B)	R 6 (B)				
	M. XI (C)	M. IX (C)			
	M. XI (A)	M. IX (A)	M. IV (A)	M. I (A)	2
				M. II (A)	
		M. IV (B)	M. II (B)	M. I (B)	
		M. IX (B)			
	M. II (C)	M. I (C)	M. XI (C)		
	M. IV (C)				
	M. IX (C)				
	M. XVI (C)				
A 2 (A)		Grahams sdg. (A)		M. I (A)	31
		M. XI (A)		M. IX (A)	
		M. XVI (A)			
Grahams sdg. (B)	²	Antonovka sdg. (B)	Kleiner Langstiel sdg. (B)	French mixed sdg. (B)	
		Bitterfelder sdg. (B)	Roter Trierer sdg. (B)	Jakobsapfel sdg. (B)	
		Litauer Pepping sdg. (B)			
		<u>M. prunifolia</u> sdg. (B)			
		M. IV	M. II	M. IX	78
		M. XVI			
A 2		Grahams sdg.	M. IV	M. IX	34
M. XVI		M. XI	M. VII		
Maurer's Dab select.		M. VIII	M. III	M. I	47
		M. XI	M. IV	M. II	
M. IX			M. XVI	M. VII	

¹ R 7, R 9, etc are German selections.

Table 1. (Continued)

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference number
	A 2		M. II	M. I	55
	M. XI		M. VII	M. IV	
	M. XVI		M. IX		
	Antonovka sdg.				
	<u>M. baccata</u> sdg.				
	<u>M. prunifolia</u> sdg.				
Chulanovka		M. III	M. VIII	M. IX	59
Krasnolistnaya paradizka					
<u>M. sargentii</u> sdg.					
<u>M. virginiana</u> sdg.					
<u>M. zumi</u> sdg.					
Beautiful Arcade 10 and 25 ³	Antonovka 8	M. VIII	Antonovka 10	Antonovka 11	50
<u>Malus robusta</u> 11			M. VII	A 2	
Maurer's Dab select.				MM. 104	
				MM. 106	
				MM. 109	
				MM. 111	
M. XVI	M. II		French Crab sdg.	M. VII	13
			M. IV		
			M. IX		
Antonovka sdg. (A)	MM. 111 (A)	MM. 104 (A)	M. II (A)		40
		MM. 106 (A)	M. VII (A)		
		MM. 109 (A)	M. IX (A)		
			M. XXV (A)		
Antonovka sdg. (B)	M. VII (Γ)	M. II (B)	Delicious (B)		
	MM. 104 (B)	M. XXV (B)	M. IV (B)		

³ Beautiful Arcade 10 and 25, Antonovka 8, 10, and 11; and M. robusta 11 are Ottawa selections.

Table 1. (Continued)

Very hardy Hardy	Moderately hardy	Tender	Very tender	Reference number
McIntosh (B)		MM. 106 (B)	M. IX (B)	40 (Contd.)
		MM. 109 (B)		
MM. 111 (B)		M. 26 (B)		
Antonovka sdg. (C)	M. VII (C)		M. II (C)	
	MM. 104 (C)			
	Antonovka sdg. (D)		Commercial sdg. (D)	
M. robusta 5 sdg.	Antonovka sdg.			60
	MM. 104	MM. 106	MM. 111	70
		MM. 109		
Antonovka sdg.	M. VII	M. II		72
MM. 104		M. XXV		
MM. 106		MM. 109		

Malling (M) and Malling-Merton (MM) clones

M. I. Very tender. One of the tenderest, if not the most tender, of apple rootstocks. The behavior of the stock is rather uniform, except for some observations in Finland (51) and in New York State (66) where the rootstock was considered hardy or moderately hardy.

M. II. Tender. Exceptions to this, where M. II was rated hardier than tender, are noted in reports from New York State (66 and 67), Finland (51), Germany (77), and British Columbia (13). In the last case reference is made to injuries due to a mid-November freeze in 1955, when the extent of injury was clearly related to the seasonal maturity of the trees. M. II is known to mature very early in autumn and

therefore may survive low temperatures in early winter better than some other rootstocks. Exposed to low temperatures in mid-winter, this rootstock is one of the tenderest, although exceptions also are known (77).

M. III. Moderately hardy to hardy. From observations in New York State (67) and Russia (46, 59) under natural conditions and the artificial freezing tests by Stuart (63), M. III appears to be among the hardiest of all clonal rootstocks compared, whereas in Germany (77, 47) this stock was rated relatively tender. M. III is considered the hardiest of the M. stocks by the Russian authors. This semi-standard to semi-dwarfing stock suckers badly and is little used.

M. IV. Tender. The behavior of the stock is not very uniform. In two instances the stock has been among the hardiest under comparison (63, 78), but in most cases it is on the same level as other tender stocks or even the most tender ones.

M. VII. Tender to moderately tender. The performance of M. VII has varied greatly between locations and seasons (67, 66). The shoots of M. VII were found relatively hardy but the roots tender in the artificial freezing experiments at Summerland (40). Karnatz (34) found M. VII relatively hardy in early winter and tender in midwinter. In the

early freeze of November, 1955, in British Columbia, M. VII was tender with few exceptions. Where direct comparisons between M. VII and M. IV are available, M. VII appears to be slightly more hardy than M. IV. Zwintzsch (77) found M. VII the most tender in a midwinter freeze.

M. VIII. Moderately hardy. Very few reports are available on hardiness of M. VIII. In Russia, M. VIII is considered to be hardier than M. IX (46, 59); in Eastern Europe it was hardier than most M. rootstocks (47); in the U.S.A., M. VIII or Clark Dwarf was considered hardy, but in the winter of 1955-56 trees with M. VIII interstock were killed or injured in some instances.

M. IX. Tender. Great variation in performance is noted between locations and seasons. M. IX matures early in autumn and its cold resistance to early freezes may be reasonably high (34) as was also noted with M. II. In midwinter, however, the rootstock is tender or very tender. In Eastern Canada (16) and Russia (46, 59), M. IX is considered the tenderest of all M. rootstocks.

M. XI. Hardy to moderately hardy. The data on hardiness of this rootstock come from Germany where it is widely used and Sweden where it is under extensive test. The cold hardiness reaction of the rootstock is rather uniform.

With but few exceptions (77), it is listed among the hardiest of the clonal stocks. The hardiness of M. XI is nearly equal to that of M. XVI and equal or slightly inferior to A 2 - a hardy Swedish rootstock. M. XI produces a slightly smaller tree than does M. XVI.

M. XVI. Hardy to moderately hardy. In most comparisons M. XVI has been classified as hardy. In a few instances it has been rated with the tender clones. M. XVI matures late in autumn and may be tender in early winter freezes (34). However, in the November freeze of 1955 in British Columbia M. XVI was, on the average, classified as hardy (13). In midwinter M. XVI attains a hardiness level that is equal or superior to any of the other M. clones.

M. XXV. Tender to very tender. This vigorous rootstock is a recent introduction from East Malling and has been tested for hardiness at the Summerland Research Station only. Following both the severe winter of 1955-56 and artificial freezing tests with shoots and roots, M. XXV has been found uniformly tender or very tender.

MM. 104. Moderately hardy. Both at Morden (70) and Summerland (72) this rootstock has been among the hardiest under the natural conditions of a killing freeze. In artificial freezing experiments (40), MM. 104 was found to

have moderately hardy shoots but tender roots. Under very severe conditions, as those provided by the snow sweeping tests at Ottawa, none of the MM. stocks survived (50).

MM. 106. Moderately tender. A small nursery planting of this rootstock survived well in the severe winter of 1955-56 (72), but other evidence indicates that MM. 106 may be relatively tender (40).

MM. 109. Tender. In the few comparisons available this rootstock has been as tender or more tender than MM. 106. The maturity of tree of this rootstock in autumn is relatively early.

MM. 111. Moderately hardy. In artificial freezing experiments at Summerland (40), this rootstock has been among the hardiest. On the other hand, at Morden (70) it was found the tenderest of the four MM. stocks compared. However, in this planting MM. 111 suffered more than the other stocks from root damage apparently caused by high soil temperatures in summer, and the root damage experienced in summer might have had certain effects on survival in winter.

Clonal rootstocks other than M. and MM. clones

A2. Hardy to moderately hardy. This Swedish rootstock has been tested mainly in Sweden and Germany; one comparison is reported from Ottawa (50) and limited exper-

ience is available from Summerland (40). In Sweden and Germany, A2 has been found to be hardy, equal to or hardier than M. XI or M. XVI. In the Ottawa snow sweeping tests (50) A2 suffered rather severely (along with Antonovka seedlings) and at Summerland this stock was moderately hardy. A2 produces trees semi-standard in size. The stock is very sensitive to magnesium deficiency in the soil.

CHULANOVKA. Very hardy. An apple variety propagated vegetatively and used as a rootstock in Russia, presumably on an experimental basis mainly (59).

MALUS ROBUSTA No. 5. Very hardy. Hardier than A2 (52) and equal to Antonovka (16). In British Columbia and Alberta, M. robusta No. 5 loses its superiority in hardiness relatively early in winter. This stock produces trees of approximately standard size.

MAURER'S DAB SELECTIONS (Dahlem's bacata-hybrids). Very hardy to hardy. Several clones of Dab selections at Ottawa (50) proved to be superior to A2 clone or Antonovka seedlings. A wider collection of clones of this series has been tested in rather extensive orchard plantings in Eastern Europe and found to have suffered very little, or no, winter injury. Nearly all of the Dab clones produce trees of standard size; one exception is the clone Dab 325, which pro-

duces trees similar to those on M. II or M. IV.

NORTHERN SPY. Moderately hardy. This clonal stock, which is used rather extensively in Australia and New Zealand, was equal in hardiness to M. XVI and superior to M. III and M. VII in one comparison in Germany (77).

Seedling rootstocks

Cold hardiness is transmitted from parent varieties to progeny, but individual seedlings from any cross may be expected to vary widely in this respect. In seedling rootstocks offered to the nursery trade, neither of the parent varieties or, at best, only the seed parent is known. Most or all seedlings listed in Table 1 have resulted from open pollination, and rather wide variation in cold hardiness, depending on the pollen parent, may be expected among different sources of seedlings of the same variety. Consequently, the hardiness level, as given for each of the seedling groups, is subject to changes.

ANTONOVKA SDG. Hardy to moderately hardy. In Germany, Antonovka seedlings have been found moderately hardy, - slightly inferior to seedlings of the Graham variety and of Malus prunifolia (31). At Ottawa, Antonovka seedlings were inferior to seedlings of Beautiful Arcade but superior to commercial seedlings (50). At Summerland, both roots and

shoots of Antonovka seedlings have been superior or equal to the hardiest clonal rootstocks in the comparisons (40).

BEAUTIFUL ARCADE SDG. Very hardy. Certain selections of Beautiful Arcade seedlings were found to be hardier than Antonovka seedlings (50). Beautiful Arcade seedlings have produced trees in size similar to those on M. I or M. II rootstocks in experiments at Kentville and Summerland (45).

CHARLAMOFF SDG. Hardy. In an experiment at Ottawa, Charlamoff seedlings were found about equal in hardiness to Antonovka seedlings, but definitely more hardy than commercial apple seedlings (French crab).

COMMERCIAL APPLE SDG. Tender. Seedlings from different sources and of unknown origin, in nursery trade are usually designated as French Crab seedlings. In spite of the diversity in origin of these seedlings, as a group they show rather uniform tenderness. Commercial seedlings were inferior not only to Antonovka seedlings and the relatively hardy clonal rootstocks such as M. XI and M. XVI (57) but also to the tender rootstock M. II (13); the latter case involves observations in many nurseries in British Columbia in 1956.

GRAHAMS SDG. Moderately hardy. Among the hardiest or the hardiest of apple seedlings included in the

comparisons by Karnatz in Germany (29,31). It is as hardy as M. XI, slightly tenderer than A2, but harder than Antonovka seedlings of German origin.

MALUS SPECIES HYBRIDS. Hybrids of the following species have been tested in Russia (59) and found to be hardy: M. baccata, M. prunifolia, M. sargentii, M. virginiana, and M. zumi.

Apple framebuilders

Table 2. Hardiness grouping of apple framebuilders

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
	Duchess	Hibernal	McIntosh		53
Charlamoff	McIntosh		Delicious		25
Duchess					
Hibernal					
Columbia	Anis	Antonovka	Anoka		12
Robin	Heyer 12	Charlamoff	Haralson		
	Hibernal	Duchess	McIntosh		
			Yellow Transparent		
Antonovka	Duchess	McIntosh	Delicious		3
Charlamoff	Yellow Transparent		Northern Spy		
	Cortland	Delicious	Astrachan		15
	Haralson	McIntosh	Northern Spy		
	Sheriff	Haas			43
Duchess		McIntosh	Delicious		17
Haralson					
Hibernal					

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
	Duchess		Delicious		23
	McIntosh				
	Yellow Transparent				
Duchess	Yellow Transparent	McIntosh		French Crab	61
		Red Astrachan			
Haralson	McIntosh	Red Astrachan	French Crab		62
Hibernal			Delicious		
Yellow Transparent					
	Anis		McIntosh		68
	Antonovka				
	Borovinka				
	Yellow Transparent				
Ananas Berzenicki	Duchess	McIntosh			24
Anoka	Melba				
Hibernal	Patten Greening				
Anoka	Haralson	Charlamoff	Canada Baldwin		37
Beautiful Arcade	Hawkeye	Duchess	Delicious		
Hibernal	Yellow Transparent	McIntosh	Golden Delicious		
		Melba			
		Sheriff			
Antonovka	Hibernal				16
M. robusta No. 5					
	Apfel aus Croncels	Danziger Kantapfel	Cox Orangen-Renette		54
	Berner Rosenapfel	Goldrenette v. Blenheim	" Goldparmane		
	Boikenapfel	Jakob Lebel	Schöner von Boskoop		

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
	Rhein. Winter-ramboor	Weisser Klarapfel			54 (Contd.)
	Roter Eiserapfel				
Anoka	McIntosh	Haas	Delicious	Golden Delicious	10
Hibernal	Melba	Yellow Transparent	Red Astrachan		
Antonovka	McIntosh				22
Charlamoff	Melba				
Hibernal					
Yellow Transparent					
<u>M. prunifolia</u> Sikora I	Anoka				28
	Dominesti				
Duchess	McIntosh	Delicious			44
Haralson	Red Astrachan				
Yellow Transparent					
Antonovka Shafran	Antonovka	McIntosh			18
Hibernal	<u>M. robusta</u> No. 5				
Beacon (A)	Duchess (A)	Haralson (A)			9
		McIntosh (A)			
	Haralson (B)	Hibernal (B)	McIntosh (B)		
		Beacon (B)			
	Cousinot (A)	Gelber Trierer Wein (A)	Roter Ziegler (A)		42
	Maunzenapfel (A)				
	Noire de Vitry (A)	Newton Pepping (A)	Transparent v. Croncels (A)		
	Pomme d'or (A)	Ruhm von Kirchwerder (A)			
	Cousinot (B)	Antonovka II (B)	Antonovka I (B)		
	Jakob Fischer (B)	Antonovka III (B)	Hibernal (B)		

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
	Wargul (B)	Fredowka (B)	Nordhausen (B)	42 (Contd.)	
		Transparent v. Croncels (B)	<u>M. prunifolia</u> sdg. (B)		
Croncels	Antonovka	Jakob Fischer			32
Maunzen	Cousinot	Pomme d'or			
	Noire de Vitry				
	Antonovka	Melba	McIntosh		75
	Borovinka				
	Antonovka	McIntosh	Northern Spy		73
Antonovka	Melba	McIntosh	Delicious		38
Beautiful Arcade	Minjon	<u>M. robusta</u> No. 5			
Hibernal					
Yellow Trans- parent					
	Antonovka	Canada Baldwin			39
	Charlamoff	Haralson			
	Hibernal	McIntosh			
		Melba			
		Winter St. Lawrence			
Antonovka	Canada Baldwin	Beacon	Golden Delicious		40
Charlamoff	Haralson	McIntosh			
Hibernal	Red Astrachan				
	Yellow Trans- parent				
Heyer 12	Hibernal	Haralson			48
		Wealthy			
	Antonovka	<u>M. robusta</u> No 5	Spartan	Golden Delicious	72
	Canada Baldwin	McIntosh			
	Haralson				
	Hibernal				

ANIS. Very hardy. Anis is one of the hardest large-fruited apples, hardier than Antonovka, Charlamoff, or Haralson.

ANOKA. Moderately hardy to hardy. Under severe conditions in Manitoba (12) it was classified as tender, but in Germany as hardy (28) or very hardy (24). The variety is reported to have dwarfing tendencies (24).

ANTONOVKA. Hardy. This variety is equal in hardiness or slightly inferior to Charlamoff and Hiberna, slightly more hardy than Haralson. In Washington State and British Columbia Antonovka has been injured occasionally by early winter freezes, but is fully hardy in mid-winter.

BEAUTIFUL ARCADE. Hardy to very hardy. In one test at Summerland the variety was equal in hardiness to Antonovka and Hiberna.

BOROVINKA. Hardy. The variety is about equal in hardiness to Antonovka.

CANADA BALDWIN. Moderately hardy. Canada Baldwin is equal in hardiness or slightly superior to McIntosh.

CHARLAMOFF. Very hardy to hardy. Charlamoff is as hardy as Duchess (25,12) or hardier (3). In an experimental planting at Summerland, Charlamoff, when used as a framebuilder, showed a tendency to produce a slightly

smaller than standard tree (45).

DUCHESS (OLDENBURG). Hardy to very hardy. The variety is about equal in hardiness to Hibernial.

HARALSON. Hardy to moderately hardy. The behavior of the variety has been variable in different locations. In Iowa (17) it was hardy, equal to Hibernial, but in Manitoba (12) it was rated moderately tender, about equal to Wealthy, Yellow Transparent, and McIntosh. In British Columbia it was found hardy in the severe winter of 1949-50, although slightly tenderer than Antonovka and Hibernial.

HEYER 12. Very hardy. One of the hardest large-fruited apples, hardier than Antonovka and Charlamoff (12); equal (12) or superior (48) to Hibernial.

HIBERNAL. Very hardy to hardy. Hibernial is relatively consistent in hardiness, similar to Charlamoff, slightly superior to Antonovka, slightly inferior to Heyer 12.

MALUS PRUNIFOLIA SIKORA TYPE 1. Very hardy. Selection from Poland for very severe winter conditions.

MALUS ROBUSTA NO 5. Hardy to very hardy. This selection is very hardy under conditions of cold and relatively stable winters, but moderately hardy to tender under winter conditions with frequent warm periods. M. robusta No. 5 may show slight graft incompatibility with some vari-

eties (e. g. Newtown, Stayman, and Winesap).

McINTOSH. Moderately hardy. McIntosh is slightly less hardy than Haralson (15, 62, 44), Yellow Transparent (3, 61), and Melba (75, 38); about equal in hardiness (61, 44) or superior (62, 52) to Red Astrachan.

MELBA. Moderately hardy to hardy. In Sweden (22) Melba is considered to be approximately equal in hardiness to McIntosh, in Russia (75) and British Columbia (38) it has proved superior. When used as a framebuilder Melba has been found to produce a tree slightly smaller than standard size (45).

RED ASTRACHAN. Moderately hardy. Red Astrachan is approximately equal in hardiness to McIntosh.

ROBIN. Hardy. The variety is hardier than any large-fruited apple varieties under severe winter conditions. When used as a framebuilder, Robin has some dwarfing effect. Robin was injured in the winter of 1955-56 in the Okanagan Valley.

WINTER ST. LAWRENCE. Moderately hardy. The variety was used as a framebuilder in British Columbia. In the severe winter of 1949-50, the variety was equal in hardiness to McIntosh, Canada Baldwin, and Haralson.

YELLOW TRANSPARENT. Hardy. The variety

is relatively uniform in its behavior. The tree matures early and can endure rather low temperatures, but under extreme conditions it is not as hardy as Antonovka, Hiberna, or Duchess (12). The bark, especially of young trees, is relatively sensitive to cold.

Pear rootstocks

Table 3. Hardiness grouping of pear rootstocks

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
	Pfänderquitte	Quince A	Quince Pill-nitz R3	Rheinland-quitte	26
		Gaucherquitte	Quince Pill-nitz R5		
		Quince Pill-nitz R1	Stroop quince		
		Quince Pill-nitz R2			
	Quince Pill-nitz 2	Quince Pill-nitz 1	Angers quince	Quince C	58
	Quince Pill-nitz 3	Quince Pill-nitz 5			
		Pfänderquitte	Quince A	Quince C	27
	Kirchensaller Mostbirne sdg.		Wildling aus Einsiedeln sdg.		29
			Wilde Eierbirne sdg.		
<u>Crataegus monogyna</u>	Pear (Hüttner) sdg. Pyrus betulifolia (Pillnitz clones)	Clapps Favorite	Alexander Lucas	Quince A	2
	Kirchensaller Mostbirne sdg.	Wilde Eierbirne sdg.	Birne WM sdg.	Französische Birne sdg.	31
		Wildling aus Einsiedeln sdg.	Lange Winterbirne sdg.	Hellmanns Melonen sdg.	
			Masselbacher sdg.		
		Quince A		Quince C	8
<u>Amelanchier canadensis</u>	Melitopolskaya quince	Severnaya quince			59

Clonal rootstocks

MELITOPOLSKAYA QUINCE. Hardy. A Russian selection.

PFÄNDERQUITTE. Moderately tender. A German selection of quince.

PILLNITZ 2 QUINCE. Moderately tender. A selection from Pillnitz, Germany.

PILLNITZ 1 QUINCE, PILLNITZ 3 QUINCE, and PILLNITZ 5 QUINCE. Tender. The Pillnitz selections are hardier than the Malling selections of quince.

PYRUS BETULIFOLIA, PILLNITZ CLONES. Hardy.

QUINCE A. Tender. Quince A is slightly hardier than Quince C. At Geneva, N.Y. (8), it is considered reasonably hardy.

QUINCE C. Very tender. Quince C is considerably more tender than pear seedlings.

SEVERNAYA QUINCE. Moderately hardy. A Russian selection.

Seedling rootstocks

KIRCHENSALLER MOSTBIRNE SDG. Hardy

WILDE EIERBIRNE SDG. Moderately tender.

WILDLING AUS EINSIEDELN SDG. Moderately tender.

Pear framebuilders

Table 4. Hardiness grouping of pear framebuilders

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
<u>Pyrus ovoidea</u>	Old Home Sacharnaja				24
Sacharnaja	Bertrams	Augustbirne "Grüne Jagd- birne	Gellerts Butter- birne Neue Poiteau	Hollandi- sche Krautbirne Hollandi sche Zuckerbirne	27
	Anjou Old Home	Bartlett	Farmingdale		44
	Gellerts Butterbirne Gute Graue Neue Poiteau Petersbirne		Bartlett Bosc		6
		Augustbirne	Gellerts Butterbirne Proskau	Charneu	33
Sacharnaja	Gute Graue Patten	Précoce de Trevoux	Clapps Favorite Doyenné de Comice	Bartlett Beurre Hardy	54
	Gellerts Butterbirne "Grüne Jagd Old Home Pabbeln	Bertrams Sacharnaja	Proskau Aver. of scion varieties (Al. Lucas, Mad. Verté, Comtesse de Paris)		20

BERTRAMS STAMMBILDNER. Hardy.

GELLERTS BUTTERBIRNE. (BEURRE HARDY).

Moderately tender.

"
GRÜNE JAGDBIRNE. Moderately hardy.

GUTE GRAUE. Hardy.

NEUE POITEAU. Moderately hardy.

OLD HOME. Hardy. Slightly harder than Bart-

lett.

SACHARNAYA. Hardy to very hardy. Used in

Eastern Germany and Poland as a framebuilder. Kemmer and

Schulz (36) noted incompatibility with the Bartlett variety.

Cherry rootstocks

Table 5. Hardiness grouping of cherry rootstocks

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
	<u>P. mahaleb</u>		<u>P. besseyi</u>	<u>P. avium</u>	11
				<u>P. pensylvanica</u>	
	Mahaleb	Mazzard			1
	Mahaleb		Mazzard		69
	Mahaleb		Mazzard		56
<u>P. fruticosa</u>	<u>P. pensylvanica</u>	Vladimir	<u>P. avium</u>		64
			<u>P. mahaleb</u>		
<u>P. Mahaleb</u>		Mazzard Hüttner HZ	Mazzard ("Bott- scher & Bergfeld)		2
			Mazzard (Denmark)		

Table 5 (Continued)

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
Mahaleb sdg.	"Hüttner 170 sdg.	Mazzard B6 sdg.	Dönnisens sdg. Mazzard L.B. 30 F 12/1 "Hüttner 53 sdg. Kleine Blanke sdg.		
	Mahaleb P.I. 193702		Mahaleb sdg.		71
	Mahaleb P.I. 194098				

MAHALEB P. I. 193702 and P. I. 194098 CLONES.

Very hardy. Cold-hardy selections have been introduced by the United States Department of Agriculture from Russia, Turkey, etc. These two clonal selections have been found superior in cold hardiness to Mahaleb seedlings.

MAHALEB SDG. Hardy. In all reported comparisons except one (64), Mahaleb seedlings were hardier than Mazzard seedlings, although the seed sources can be expected to be different in each comparison. Seedlings of very hardy species, such as Prunus fruticosa and P. pensylvanica, have been hardier than Mahaleb seedlings (64).

MAZZARD HÜTTNER CLONES. Moderately tender. Of the several Hüttner selections of Mazzard (Prunus avium), Hüttner HZ clone was compared with Mazzard seedlings of various sources and found superior to the latter. Karnatz (30) used seedlings of certain other Hüttner selections

and found Hüttner 170 relatively hardy.

MAZZARD F12/1 CLONE. Tender. This English selection is approximately equal in hardiness to the average of Mazzard seedlings. In a comparison at Summerland following the winter of 1955-56, F12/1 proved to be equal in hardiness to the tender varieties of cherries, such as Bing and Star.

MAZZARD SDG. Tender. Since sweet cherry varieties are uniformly cold tender, Mazzard seedlings of various sources cannot be expected to differ much in hardiness.

Cherry framebuilders

No published information is available on relative hardiness of various cherry stocks that might be used as framebuilders for sweet cherry. Those listed below are known to be hardier than sweet cherry varieties.

MAHALEB CHERRY. Brase (7) showed that sweet or sour cherries grafted in the trunks of Mahaleb seedlings at 26 inches from ground produced smaller than normal trees. At 15 years of age trees on Mahaleb trunks were half the size of trees on Mazzard trunks (8).

PIN CHERRY (PRUNUS PENSYLVANICA). At Summerland, trees of Bing and Lambert budded in the frame of pin cherry on Mazzard root produced weak growth which could not support the heavy crop the trees set. The perform-

ance of Bing was better than that of Lambert.

SOUR CHERRY. Stockton Morello has been used in a small way as a rootstock for sweet cherries in California for several decades. It produces trees about one-half the height of the same varieties growing on Mazzard stocks (8). Montmorency and Northstar cherries have been used lately as hardy, dwarfing framebuilders for sweet cherries. Russian authors indicate that sweet cherries on sour cherry stocks are not long-lived (65).

Plum, peach, and apricot rootstocks

Table 6. Hardiness grouping of plum, peach, and apricot rootstocks

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
<u>P. besseyi</u>	<u>P. Americana</u>		Marianna plum	Myrobolan plum Peach sdg.	14
		Hüttner 3 (St. Julien)	Kroosjes blue	Ackermann	58
		Mussel plum	Kroosjes yellow	Brüssel	
		Belle sdg.		Elberta sdg.	6
		Early Crawford sdg.		J. H. Hale sdg.	
		Iron Mountain sdg.			
<u>P. americana</u>	Marianna plum	<u>P. davidiana</u>	Southern Natural peach sdg.	Peach (Peento?) sdg. Elberta sdg.	74
		Myrobolan plum			

Table 6 (Continued)

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
	Ackermann Pershore	Kroosjes yellow	Kroosjes blue Brompton		24
	Brompton (A)	Ackermann (A)	Myrobolan sdg. (A)	"Brüssel (A)	26
	Common mussel (A)	Damascena noir (A)			
	Damascena blanc (A)	Kroosjes yellow (A)			
	Hüttner 3 (A)	Myrobolana alba (A)			
	Kroosjes blue (A)	Ackermann (B)			
	St. Julien Orléans (A)	Brüssel (B)			
	Common mussel (B)	Damascena blanc (B)	Brompton (B)	Peach sdg. (B)	
	Hüttner 4 (B)	Damascena noir (B)	Myrobolan sdg. (B)		
	Marianna (B)	Hüttner 3 (B)	St. Julien Orleans (B)		
	Myrobolana alba (B)	Kroosjes blue (B)			
		Kroosjes yellow (B)			
		Ackermann	Myrobolan		57
	Pershore	Brompton	Ackermann	"Brüssel	27
		Hüttner 4	Damascena noir sdg.		
		Kroosjes blue	Kroosjes yellow		
		Myrobolana alba	Myrobolan sdg.		
		St. Julien d'Orléans sdg.			
		St. Julien sdg.		Myrobolan sdg.	36

Table 6 (Continued)

Very hardy	Hardy	Moderately hardy	Tender	Very tender	Reference Number
		Hüttner 4 (A)		Ackermann (A)	2
		Damas noir (B)	Myrobolan sdg. (B)		
		Greengage sdg. (B)			
	Wangenheim sdg. (C)	Wagenstädter sdg. (C)	Greengage clone (C)	Ackermann (C)	
			Greengage sdg. (C)		
			Myrobolan sdg. (C)		
		St. Julien (D)	Ackermann (D)	Brüssel (D)	
			Myrobolan (D)		
		<u>P. cerasifera</u> sdg. (A)	<u>P. domestica</u> sdg. (A)		30
	Hüttner 35/V/8 (B)	Myrobolan sdg. (B)	Damascena blanc sdg. (B)		
	Myrobolan, Ottensen 6 sdg. (B)	St. Julien, Orleans, sdg. (B)	Damascena noir sdg. (B)		
<u>P. besseyi</u>	<u>P. spinosa</u>	Siberian apricot			59
	Apricot sdg.		Myrobolan sdg.		35

Clonal rootstocks

ACKERMANN PLUM. Tender. The reports on hardiness of this stock are contradictory. In the majority of cases Ackermann plum has been tender.

BROMPTON PLUM. Moderately tender. Vigorous stock.

BRÜSSEL PLUM. Very tender. Moderately vigorous.

HÜTTNER IV PLUM. Moderately hardy. A Ger-

man selection.

KROOSJES PLUM. Moderately tender. Two types are in use in Europe: Kroosjes yellow and Kroosjes blue. Observations are contradictory in respect to their relative hardness. Kroosjes plum as a rootstock produces relatively weak trees.

MARIANNA PLUM. Moderately hardy. This rootstock is hardier than Myrobolan plum. European Marianna plum as a rootstock produces a relatively weak tree. Certain Californian selections of Marianna plum, such as Marianna 4001, are vigorous.

MYROBOLAN PLUM. Moderately tender. Myrobolan is less hardy than St. Julien and Marianna plums. Vigorous rootstock.

PERSHORE PLUM. Hardy. The two sources of information available (24,27) indicate this stock as one of the hardest among plum rootstocks. It is a vigorous stock.

Seedling rootstocks

DAMASCENA PLUM SDG. Tender. The records available do not indicate any difference in hardness between the two types, Damascena blanc and Damascena noir.

MYROBOLAN PLUM SDG. Moderately tender. Myrobolan seedlings are less hardy than those of Wangenheim

and Wagenstädter plums; equal to or slightly inferior to St. Julien plum seedlings.

PRUNUS AMERICANA SDG. Very hardy.

PRUNUS BESSEYI SDG. Very hardy.

ST. JULIEN PLUM SDG. Moderately hardy.

This rootstock is slightly hardier than Myrobolan seedlings.

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